SECTION 10

FROM PLACE TO PLACE

OUTCOME: WHAT STUDENTS WILL LEARN

- How a distribution system works.
- How to read a map of the distribution system.
- How to calculate how fast water can get to their home.
- What the layout of water mains says about the population of an area.

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Core Content Standards

Math

MA-E-1.1.2 The operations of addition, subtraction, multiplication and division.

MA-E-3.1.3 The process of using data to answer questions.

MA-E-3.2.1 Pose questions that can be answered by collecting data.

MA-E-3.2.5 Make predictions and draw conclusions based on data.

MA-E-3.3.1 How data are used to draw conclusions.

MA-M-1.2.2 Compute large and small quantities and check for reasonable and appropriate computational results.

Science

SC-M-1.2.2 An object remains at rest or maintains a constant speed and direction of motion unless an unbalanced force acts on it.

Social Studies

SS-M-4.2.1 Places can be made distinctive by human activities that alter physical features.

SS-E-4.3.2 Humans usually settle where there are adequate resources to meet their needs.

SS-E-4.4.3 The physical environment both promotes and limits human activities.

SS-M-4.4.1 Technology assists human modification of the physical environment.

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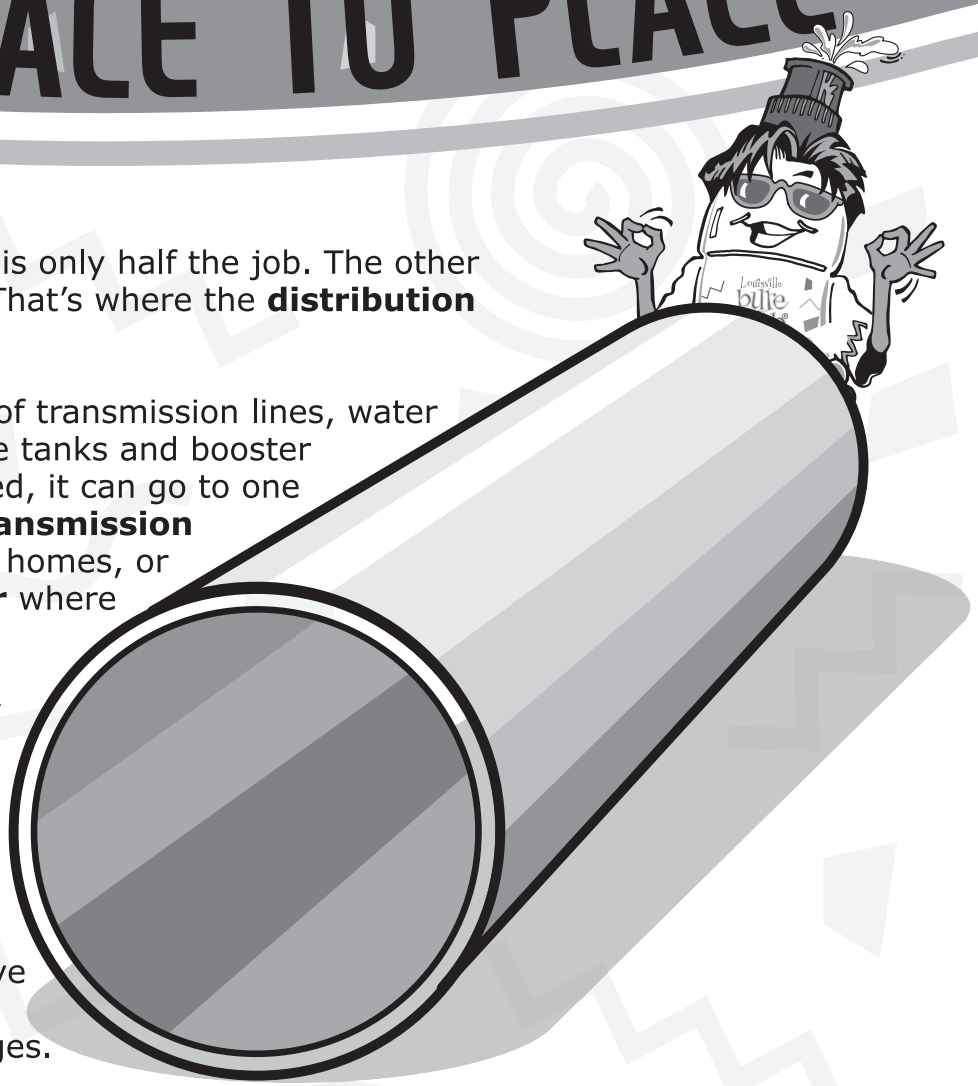
From Place To Place

Distribution System

Making good safe drinking water is only half the job. The other half is getting the water to you. That's where the **distribution** system comes into the picture.

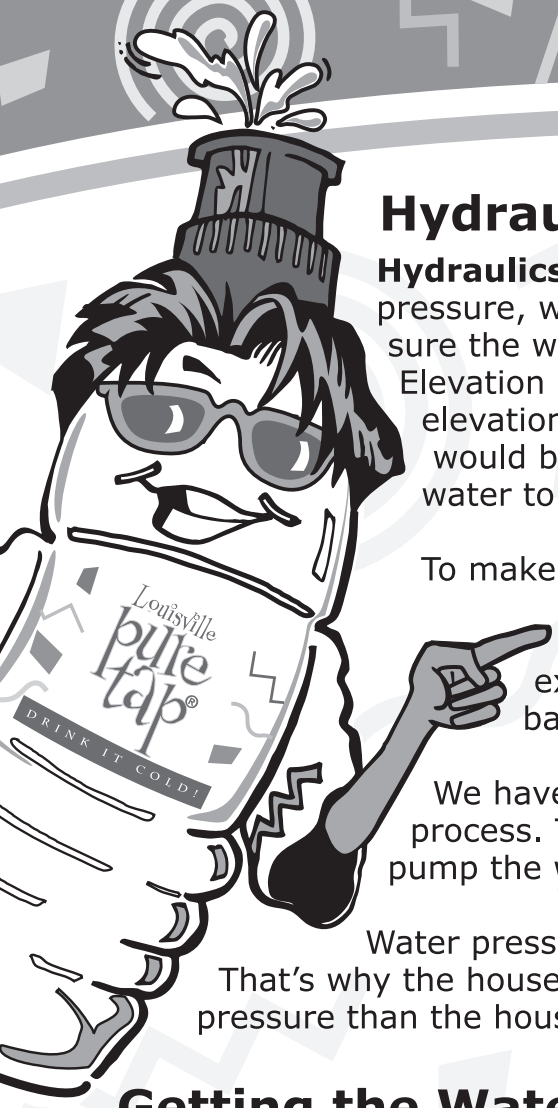
The distribution system consists of transmission lines, water mains, pumping facilities, storage tanks and booster stations. Once the water is treated, it can go to one of several places: directly into **transmission mains** that supply businesses or homes, or to a reservoir or **elevated tower** where it's stored until you need it.

The distribution system generally follows the street pattern. But the type of development (homes or businesses) determines how we transport and store the water. We also have a redundant system – that means if there's a problem or a pipe breaks, we have ways to re-route the water to avoid long periods of water outages.



Now that's a lot of pipe!

Louisville Water Company has more than 3,600 miles of **water main** in its distribution system. That's enough pipe to go to Destin, Florida and back almost three times, or enough pipe to travel to the Grand Canyon and back. So how does it all work? Two important words, **hydraulics** and **gravity**.



Hydraulics

Hydraulics is all about flow rate and **pressure**. Without enough pressure, water can't move to higher elevations. We have to make sure the water gets enough pressure, enough push, to reach everyone. Elevation plays a big role in pressure – generally the higher the elevation, the lower the pressure. If Jefferson County were flat it would be easy – we could use one storage tank and then pump the water to everyone. But that's not the case.

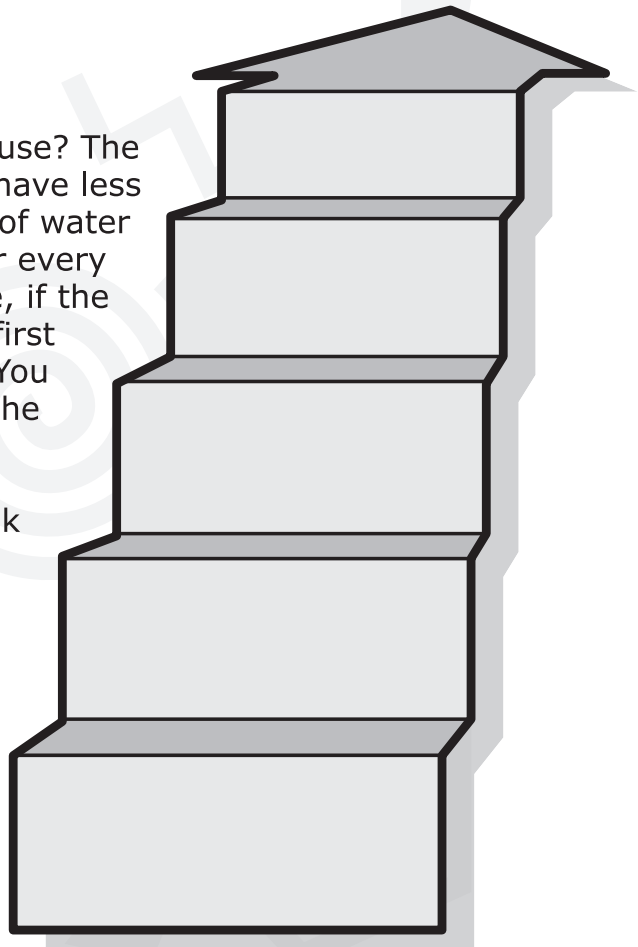
To make sure we have enough pressure [the minimum is 30 pounds per square inch (**psi**), the maximum is 100 psi as required by Kentucky] we use electric pumps to add energy to the existing system. We've divided the county into pressure zones, based on the elevation, or the height above sea level.

We have huge electric pumps at our treatment plants to start the process. There are booster pump stations throughout the county to pump the water from the treatment plants to the tanks.

Water pressure can diminish as it travels along the miles of pipe. That's why the house at the end of the neighborhood might have less water pressure than the house at the front.

Getting the Water Upstairs

How does the water get to the second floor of your house? The pressure in the pipe pushes it upstairs. But often you have less water pressure on the second floor. We aim for 40 psi of water pressure when we deliver the water to your house. For every 2.31 feet the water rises, it loses one psi. For example, if the shower on the second floor is 20 feet higher than the first floor, the pressure would be reduced by almost 9 psi. You get a higher pressure shower in the basement where the water flows down!



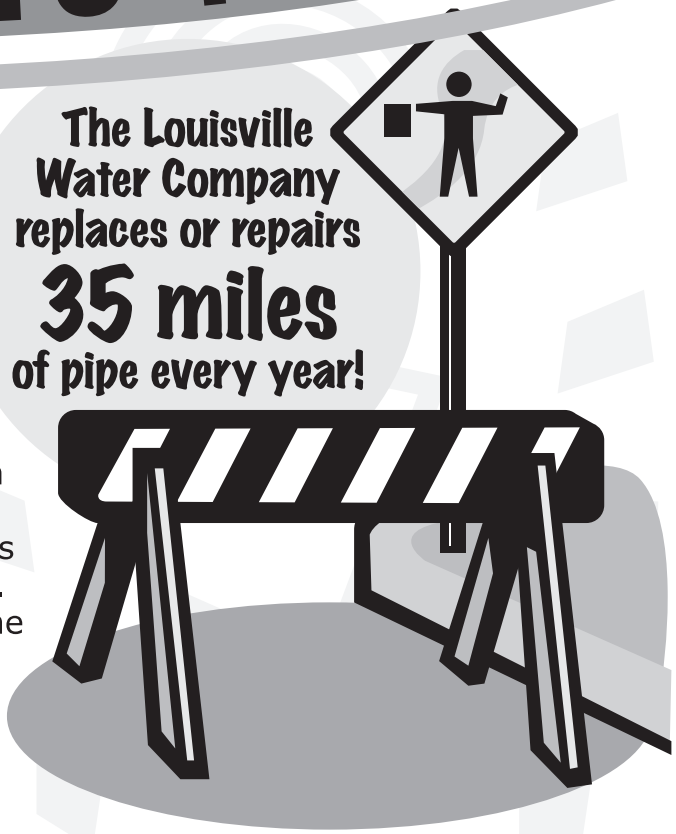
Hydraulics also plays a role in high-rise buildings. Think about a 50-story building. These buildings incorporate the same type of booster pumps we use in our system on a smaller scale. High-rise buildings must install the pumps to make sure there's water on the 50th floor.

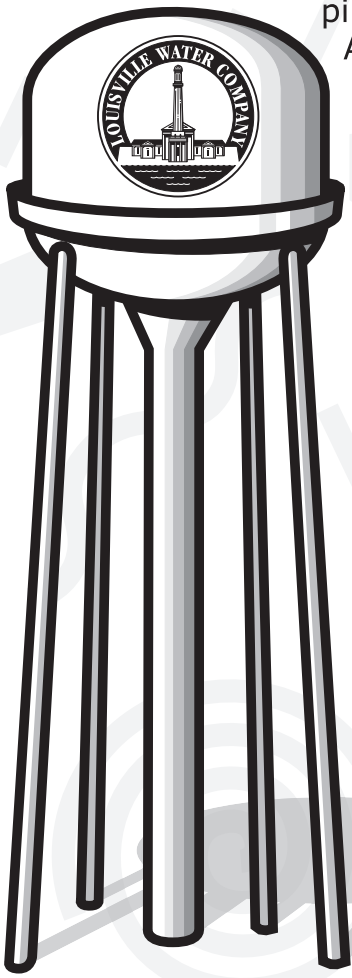
Gravity plays a role in water pressure. As water travels downhill, it gains pressure. That's why a house in a lower valley may have higher water pressure than a house on a high hill. The house on the hill would need a booster pump to keep the pressure up.

FROM PLACE TO PLACE

Water Mains

Water mains are the pipes – the vehicle - that carry water throughout our system. The mains that leave the treatment plants and the ones that carry large volumes of water are called transmission mains. We have pipes as big as 60 inches in diameter. The closer we get to your house, the smaller the water main. This assures we have enough pressure coming into your house. The water mains that come into a neighborhood can be 6 to 12 inch pipes. The pipes that come in your house can be as small as 3/4 of an inch. Sometimes these pipes break. That's called a water main break. Extremely cold weather or dry weather can cause the pipes to break. Sometimes the age and wear of a pipe can cause a break. The average life of a water pipe is about 70 to 100 years. We do have a few pipes that were around when Abraham Lincoln was President!



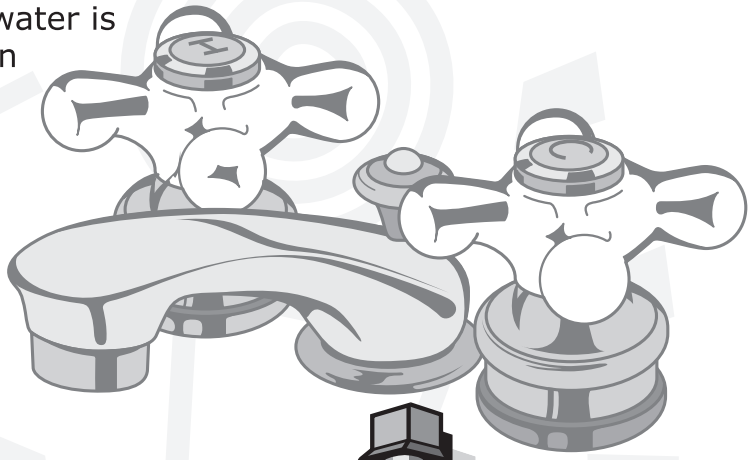


Elevated Storage Tanks and Gravity

If you drive around the county, you'll notice we place elevated storage tanks on the tops of hills. The goal is to place the water tank higher than the house on the highest hill. Some of the tanks hold a million gallons; one tank holds 10 million gallons. How do the tanks work? We pump the water to the storage tank and fill the tank (usually at night when water usage is low). Then we let gravity go to work. Once the tank is full, the water flows down through a pipe that connects to the water mains. The storage tanks give us a reserve of water. They are designed to store enough water for consumption and firefighting. An elevated tank can take on several designs; some are on a pedestal, others can be on the ground. If you've traveled south on I-65 you may have seen the Peach Water Tank in Alabama. In Texas, there's even a tank shaped like a ketchup bottle!

The Role of the Faucet

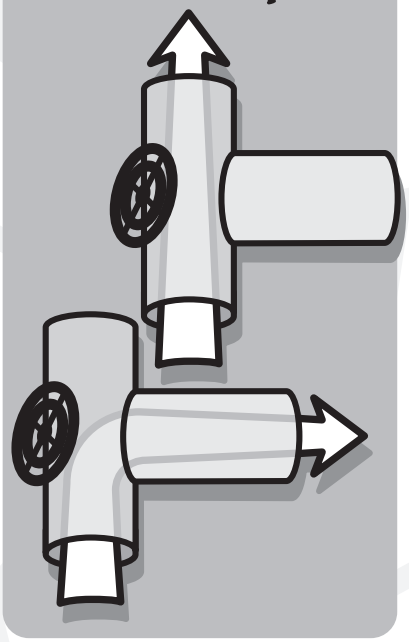
There's always water in the water mains. The water is under pressure so it has energy. When you turn on the faucet, you release the energy. That's why the water comes out of the faucet.



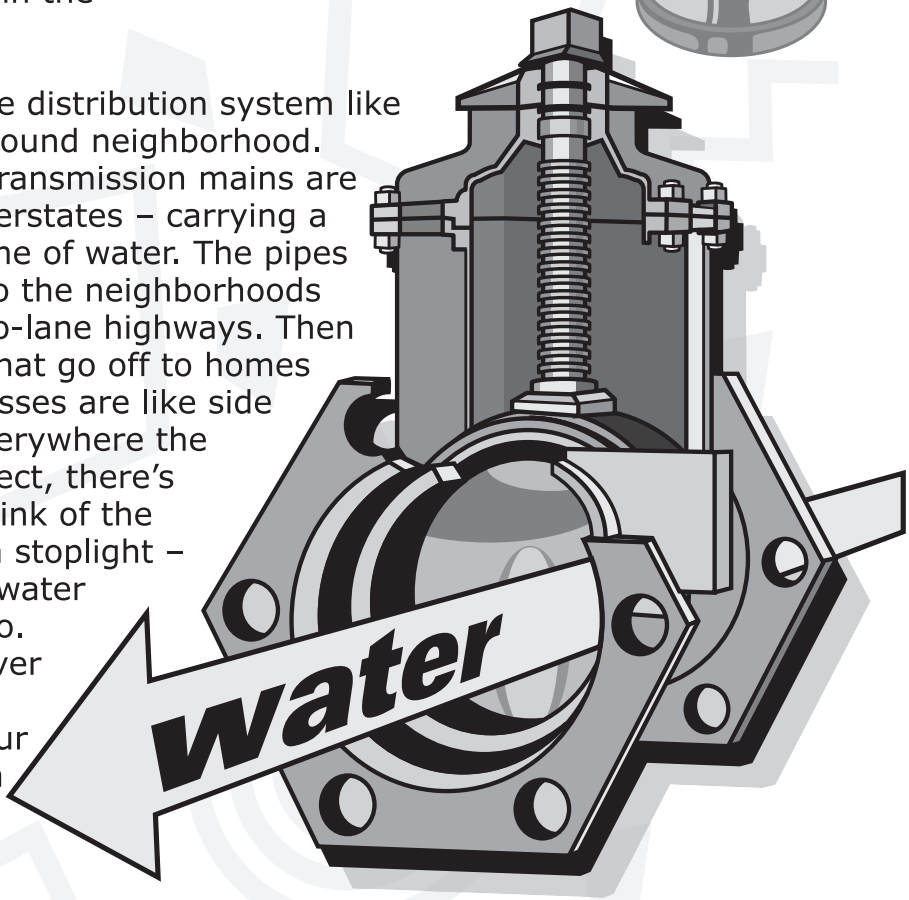
The Very Important Valves

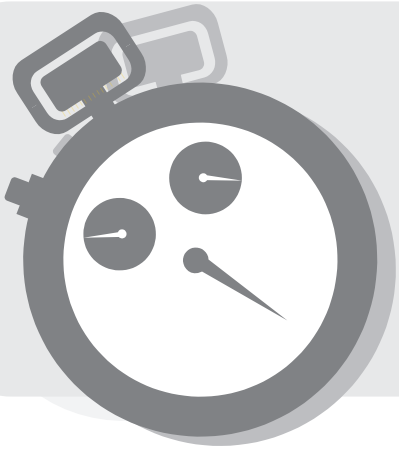
Besides the pipe, the **valve** is the most important thing to make the distribution system work. At every intersection of pipe, there's a valve that points the water in the right direction.

Valves redirect the water's path



Think of the distribution system like an underground neighborhood. The huge transmission mains are like the interstates – carrying a large volume of water. The pipes that go into the neighborhoods are like two-lane highways. Then the pipes that go off to homes and businesses are like side streets. Everywhere the pipes connect, there's a valve. Think of the valve like a stoplight – telling the water where to go. We have over 25,000 valves in our distribution system.





How fast does water go?

It takes about two days to make drinking water. But it can take up to a week to get the water to your house, depending on where you live. The **velocity**, or speed, of our water in the pipes is about five feet per second. There is 5,280 feet in a mile. That means it takes about 17 minutes for the water to travel a mile in the pipe.

FROM PLACE TO PLACE

How Does a Fire Hydrant Work?

Louisville Water Company's two priorities are health and safety. We must provide good safe drinking water and make water available for fire-fighting. We maintain over 17,000 fire hydrants as part of our distribution system. A fire hydrant is mounted directly on a water main. The valve is always closed. When a firefighter turns on the hydrant – opens the valve – a tremendous amount of pressure is released. In Jefferson County, the fire hydrants can release 750 gallons of water every minute. We have crews that go out on a daily basis and measure the flow of the fire hydrants to make sure they work properly.

In Jefferson County, a fire hydrant can release **750 gallons** of water every minute!

Distribution in Other Parts of the U.S.

New York City is a great example of distribution for a big city. The city takes water from as far as the Delaware River and transports it using gravity tunnels. The city is in the process of building a 60-mile underground tunnel to add another source of water delivery.

In southern California, where there's very little rain, the state constructed a 450-mile **aqueduct** to take water to Los Angeles.

WATER WORDS

Aqueduct: An artificial channel that supplies water to a community from a distance.

Distribution: moving things from one place to another.

Elevated water tank: Tank constructed at a high point that stores water.

Gravity: the force of attraction by which things tend to fall towards the center of Earth.

Hydraulics: engineering that deals with the distribution and movement of liquids, mainly water.

Pressure: the amount of force pushing on a surface.

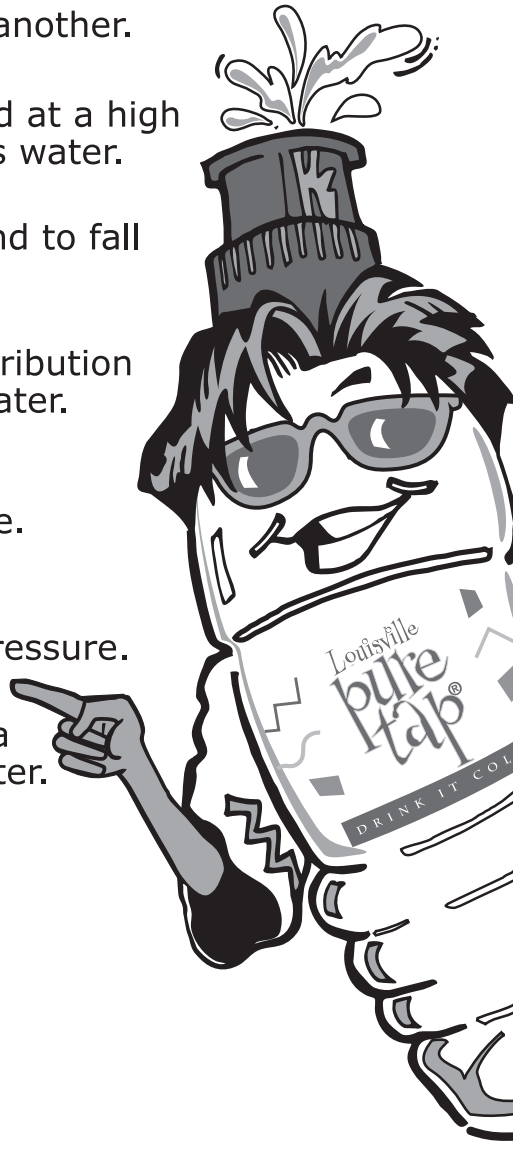
PSI: pounds per square inch. Used to measure water pressure.

Transmission main: a pipe that carries a large volume of water.

Valve: device that controls the flow of water.

Velocity: the speed of something.

Water main: a pipe that carries water.



Activity #1: "Make It Move"

Objective:

Students will understand how gravity and force work to move water from place to place.

Time: 45 minutes

You'll need:

- A variety of cylinders – empty paper towel and toilet paper rolls, mailing tubes, pieces of pipe, etc.
- Masking tape
- Hair dryers
- Funnels
- Balloons
- Marbles
- Rubber bands

Here's what to do...

1. Divide students into groups of four.
2. Relay the challenge – the town needs water. Students need to design a distribution system to get the water from the water treatment plant to the homes. They must use different sizes of "pipes". How the distribution system looks, is up to them.
3. The marbles represent the water. You can designate where the water treatment plant is located (maybe a table) and where the homes might sit (could be another table or a place across the room). The funnel represents a water tank, to hold a large amount of water.
4. You can take this experiment one step further and do cut-outs that represent businesses, homes, hospitals, fire hydrants, etc. Have the students design the system to get water to each.

Depending on how students design the system, they may need some type of "force" to move the water. The hair dryers and balloons can represent the force.

Give a copy of the following page to each student or group to help guide them through this experiment.

"Make It Move"

Your town needs water!
Let's use the scientific method to design a water distribution system

1. Ask a question. What do you want to know?

2. Make a prediction. What type of distribution system will do the best job?

3. Design the experiment.

4. Make observations – collect and organize your data.
   Did the water (marbles) make it from the water treatment plant to the house?

   If the answer's no, why?

   What direction of the pipe made the water (marbles) move faster?

   What could make the water (marbles) go even faster?

5. Make sense of the experiment, what's your conclusion?

Make it Move! (Continued)

After you do the experiment, apply it to the real world!

In a town, where should the water treatment plant be located – on the top or bottom of a hill? _____

_____

Explain how gravity helps water move. _____

_____

_____

Explain how force is involved to move water. What force did you use in this experiment? _____

_____

Where do you place a water tank and why? _____

_____

_____

Explain how the location of a building or home affects water pressure.

_____

_____

Think about where your home or school is located. Is it on the top or bottom of a hill? Is there a water tank near-by? _____

_____

Think about the high-rise buildings in your town. How does water get to the 20th floor of the Humana building? _____

_____

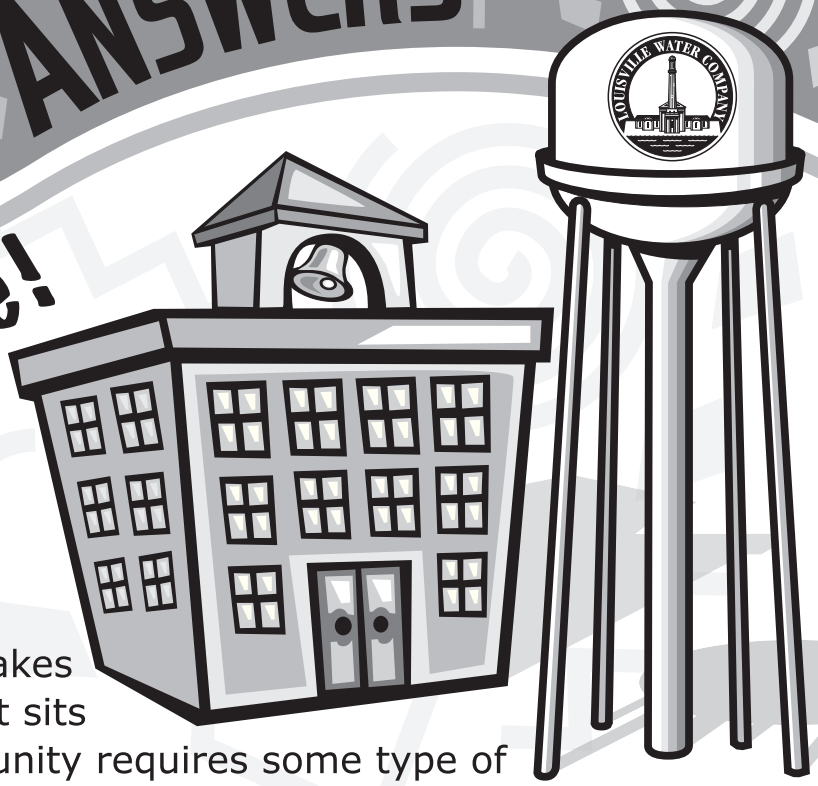
_____

_____

_____

WORKSHEET ANSWERS

Make it Move!



Students should learn that gravity plays an important role in moving water. The layout of the pipes determines how fast the water will move. A pipe installed downhill makes water move faster than a pipe that sits flat. Moving water across a community requires some type of force – the hairdryer, the air in the balloon, etc. For a water utility, that force is an electric pump to boost the water up. Once stored in an elevated water tank, gravity helps the water to go from the tank down into the pipes.

• In a town, where should the water treatment plant be located – on the top or bottom of a hill? **A water treatment plant is located in an elevated area.**

• Explain how gravity helps water move. **Gravity helps water move from a higher point (treatment plant or a water tank) to a lower point.**

• Where do you place a water tank and why? **A water tank is generally set at higher elevation than any building in the community. Since it's at a higher point, the water in the tank can move with gravity into the water mains in the ground. A water tank could be placed on ground level. However, it would take an additional pump to push the water through the pipes.**

• Explain how the location of a building or home affects water pressure. **A home at the lowest point, the bottom of a hill should have the greatest water pressure. The house at the top of a hill would have the lower pressure. Some type of force would help boost the pressure to the house.**

• Think about where your home or school is located. Is it on the top or bottom of a hill? Is there a water tank near-by?

From Place to Place

This section shows fun ways to incorporate math and art.

Here are some ways to expand the learning in your class!

1. Have students design an elevated water tank. (Some elevated tanks stand on a pedestal, some are shaped like a peach, a ketchup bottle or just a round tank sitting on the ground.) What design could become a landmark for their neighborhood?

2. There are 3,600 miles of water main in Louisville Water Company's distribution system. Have students determine how far that really is. You can use the example in the teacher notes (Grand Canyon and Destin) or come up with one of your own.

3. Figuring pressure – As water moves up, it loses pressure. For every 2.31 feet water moves up, it loses one psi. Have students determine how much pressure is lost if water moves up 16 feet to the second floor of a home.

4. Think questions. Pose the following questions to your class:

   How does water get to the 25th floor of the Humana Building in downtown Louisville? *(High rise buildings install booster pumps that help push the water up.)*

   Where do you get the strongest shower in your house – on the first floor, the second floor or in the basement? *(The strongest shower would probably be in the basement because the water is flowing down. The second floor would most likely have the weakest shower because, as water moves up, it loses pressure.)*

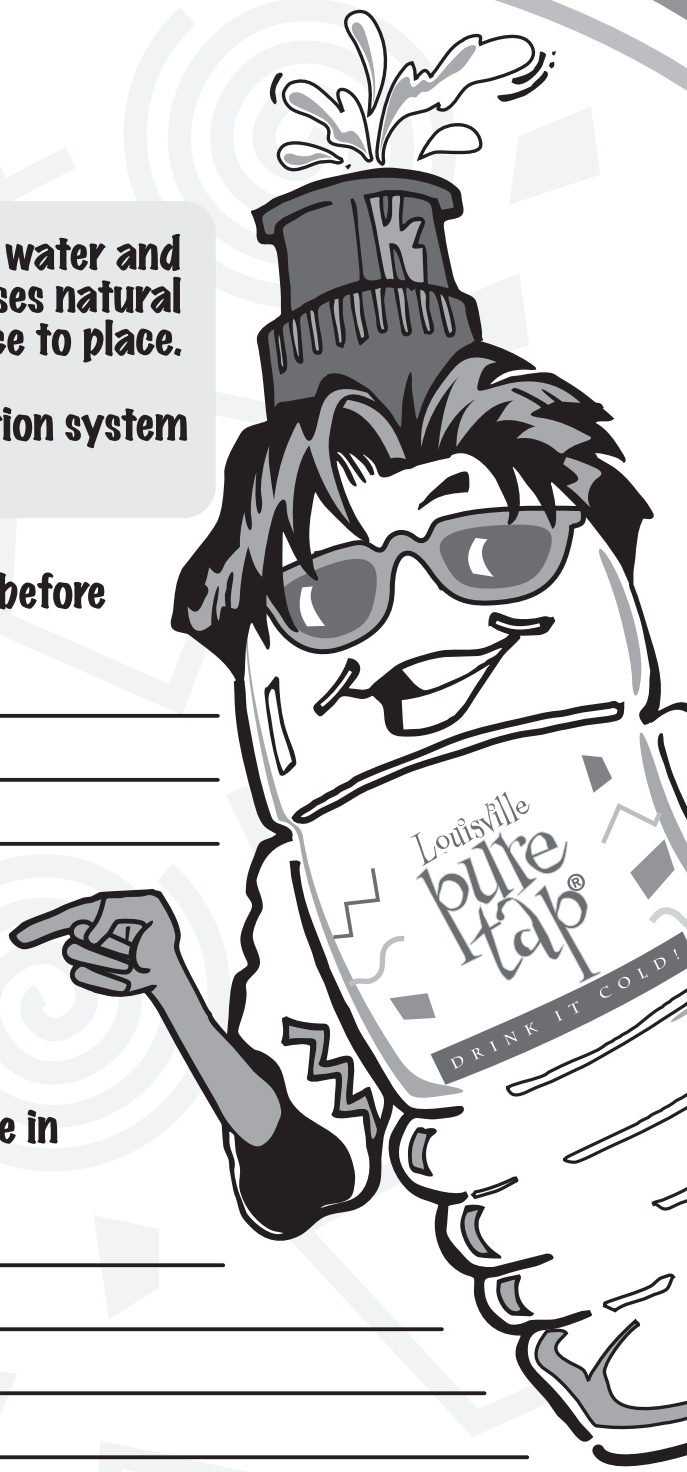
   Why do we fill the elevated storage tanks at night? *(That's when water usage is at its lowest. We fill them overnight to make sure there's plenty of water in the morning.)*

   During the summer, if everyone in the neighborhood is using water at the same time to water plants, fill the swimming pools and water the lawn, what are the possible consequences? *(In the summer we have to monitor the water pressure carefully. When lots of people are taxing the system, the pressure can drop.)*

Open Response Question

A water utility's job is to produce safe drinking water and deliver the water to its customers. The utility uses natural and man-made forces to move water from place to place.

You have been asked to design a water distribution system for your community.



A. Briefly describe two things you must consider before putting the pipe in the ground.

B. Explain how each would impact the use of force in delivering the water.

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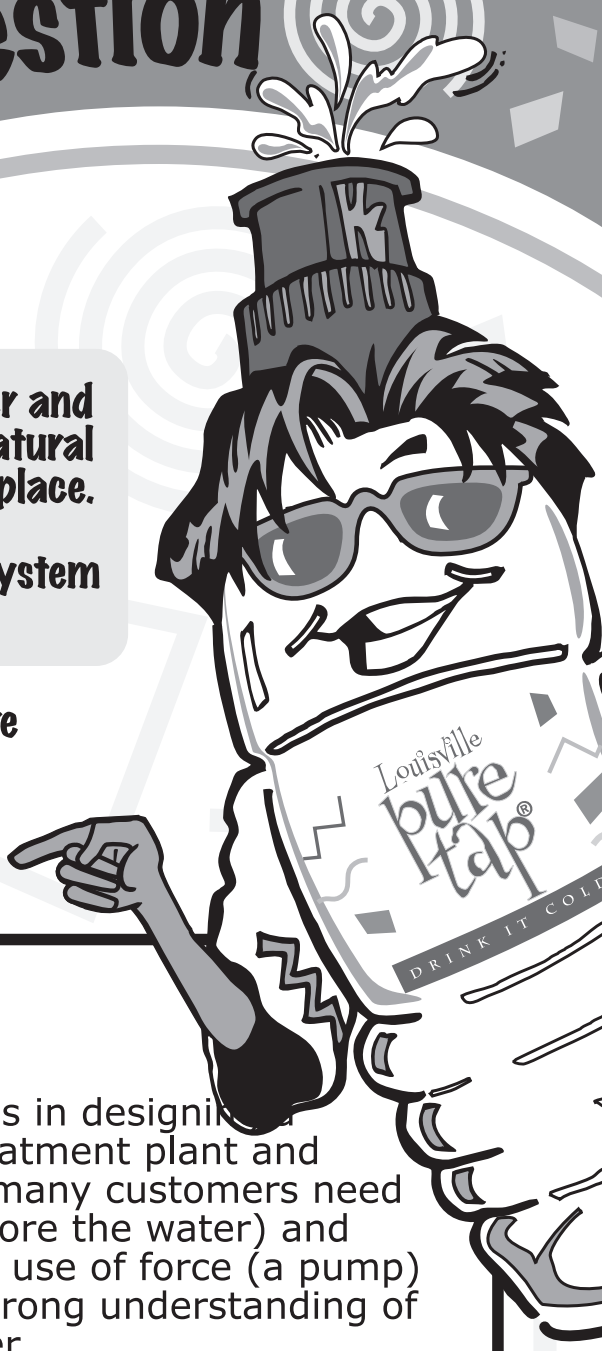

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B. Explain how each would impact the use of force in delivering the water.

Scoring Guide

4–Student correctly identifies two considerations in designing a distribution system (location of the water treatment plant and customers, is the area flat or elevated, how many customers need water, is an elevated tank required to help store the water) and explains in detail how each would impact the use of force (a pump) in delivering the water. Response shows a strong understanding of how gravity and pressure work to move water.

3–Student correctly identifies two considerations in designing a distribution system (location of the water treatment plant and customers, is the area flat or elevated, how many customers need water, is an elevated tank required to help store the water) and has a general understanding how each would impact the use of force. Response shows a general understanding of how gravity and pressure work to move water.

2–Student correctly answers part a or b OR responses in parts a and b are limited.

1–Student's response is minimal.

0–No response or totally incorrect or irrelevant.

From Place To Place

Check out these opportunities to keep the learning flowing!

Extra, Extra!!!

Books:

Zubrowski, B. (1981). *Water pumps and siphons.* Boston, MA: Little Brown. *Information and models on constructing water pumps.*

Cobb, V. (2000). *Squirts and spurts.* New York, NY: Millbrook Press.

Web sites:

www.eddiefiles.org/mathtrails/nycwater *Section 9 talks about water tanks in regards to New York City.*

www.uwin.siu.edu/ucowr/hydro/ Explanation of hydrology and the jobs hydrologists do.

Louisville Water Company Opportunities:

www.tappersfunzone.com *Click on "Teacher Tools" for a supplement to this section.*